quantitatively with that predicted by a simple sum of the partial volumes of the amino acids present in the pore when it stalls due to its primary charge. Our analysis suggests that the majority of the protein molecules were linear or looped during translocation suggesting that physiologically relevant potentials can unfold proteins. Our results suggest that the nanopore translocation physics and signals are sensitive enough to distinguish between proteins based on the excluded volume of a local segment of the polypeptide chain and the primary sequence of charges.

3343-Pos Board B390

Controlled Molecular Transport through Nanofilters with Tapered and Cylindrical Pores

Nazar Ileri[1,2], Michael Wiederoder[3,2], Pieter Stroeve[1], Sonia Letant[2], Jerald Britten[2], Hoang Nguyen[2], Cindy Larson[2], Rodney Balhorn[2], Michael Shirk[2], Saleem Zaidi[4], Ahmet Palazoglu[1], Roland Faller[1], Joseph W. Tringe[2].
[1]University of California Davis, Davis, CA, USA, [2]Lawrence Livermore National Laboratory, Livermore, CA, USA, [3]Michigan State University, East Lansing, MI, USA, [4]Gratings, Inc., Albuquerque, NM, USA.

Many applications in molecular separation and sensing technology now require devices with uniformity at the nanometer scale over macroscopic areas. Advanced methods for fabrication and manipulation of such artificial tools can greatly increase process speed, selectivity and efficiency. In this work, we present a new synthesis technique for creating ~mm2 arrays of uniformly tapered nanopores. We investigate the effect of pore size (50-800nm), geometry and surface functionalization on diffusion rates of biomolecules through synthesized membranes. Results are compared against state-of-the-art polycarbonate track etched (PCTE) membranes and other filter technologies. Mass transfer rates are shown to increase up to 15x with tapered geometries compared to cylindrical geometries. Experimental results are supported with molecular calculations.

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. LLNL-ABS-407641.

3344-Pos Board B391

Quantized ionic conductance in nanopores

Michael Zwolak[1], Johan Lagerqvist[2], Massimiliano Di Ventra[2].
[1]Los Alamos National Laboratory, Los Alamos, NM, USA, [2]University of California - San Diego, La Jolla, CA, USA.

We study ion transport through nanopores via molecular dynamics calculations. Due to the confined geometry and large local field of a single ion, the nanoscale atomic configurations of species influence the ionic conductance. In particular, hydration layers that form around ions in aqueous solution create a series of energy barriers to ion transport. As an ion enters the pore, these hydration layers have to be partially broken due to steric restrictions of the pore. The breaking of the layers proceeds in a highly nonlinear, step-like fashion, giving rise to a strong nonlinear dependence of the electrostatic energy barrier on the pore diameter and therefore also a step-like conductance. We discuss this effect as well as the conditions under which it may be experimentally observed.

3345-Pos Board B392

Effect of Valence and Concentration of Counterions on Electrophoretic Mobility of DNA in a Solid-State Nanopore

Binquan Luan[1], Aleksei Aksimentiev[2].
[1]IBM, T. J. Watson Research Center, Yorktwon heights, NY, USA, [2]University of Illinois at Urbana-Champaign, Urbana, IL, USA.

Controlling the electrophoretic mobility of DNA in a solid-state nanopore is critical to the development of the nanopore technology for sequencing DNA because, under typical experimental conditions, DNA moves through a nanopore too fast for its sequence to be detected. One could expect that increasing the electrostatic screening of the DNA charge in a nanopore would reduce the force driving DNA through and consequently the DNA translocation velocity. In free solution electrophoresis experiments, increasing either the valence or the concentration of counterions in an electrolyte was shown to affect mobility of DNA. Through extensive all-atom molecular dynamics simulations, we investigated the feasibility of controlling electrophoretic mobility of DNA in a solid-state nanopore. In our simulations, a double stranded DNA molecule is placed in the center of a 3-nm-radius nanochannel. The system is solvated in an electrolyte containing either Na(+), Mg(2+), spermidine(3+) or spermine(4+) ions. An external electric field is applied and the resulting displacement of DNA is recorded. We have found that the valence and concentration of counterions can dramatically alter the electrophoretic mobility of DNA in a nanopore. In monovalent or divalent electrolytes, increasing the concentration was found to decrease the electrophoretic mobility, whereas in spermidine and spermine electrolytes, the direction of the DNA motion could be reversed. Analysis of the interaction between DNA and the surrounding electrolyte revealed that the reduction of the electrophoretic mobility is caused not only by the presence of counterions, but also by the hydrodynamic drag of an electro-osmotic flow near the DNA surface.

3346-Pos Board B393

Translocation Studies of Single Strand-DNA Oligomer Complexes with ds-DNA Markers Using Solid-State Nanopores

Venkat Balagurusamy, Paul Weinger, Sungcheol Kim, Xinsheng Ling.
Brown University, Providence, RI, USA.

We carried out solid-state nanopore experiments on designed single-stranded DNA molecule complex with double-stranded segments. We have designed short oligomers of single-stranded DNA of about 130 bases long each with 12-bases long sticky ends that are complimentary to those on one end of other oligomers to form ds-DNA regions by Watson-Crick base-pairing in these regions. Such a design facilitates the formation of a chain of single strands DNA with ds-DNA regions interspersed. In order to slow down the translocation speed of these complexes through solid-state nanopores that could enable one to identify the ds-DNA region markers in the blockage current signal during translocation, we have attached these ss-DNA complexes with a polystyrene bead on one end. We present the results of our preliminary studies that show that the signature of these ds-DNA region markers could be identified.

3347-Pos Board B394

Control of Ionic Transport through an Ionic Transistor based on Gated Single Conical Nanopores

Eric B. Kalman[1], Olivier Sudre[2], Zuzanna S. Siwy[1].
[1]UC Irvine, Irvine, CA, USA, [2]Teledyne Scientific & Imaging LLC, Thousand Oaks, CA, USA.

Control of ionic transport through nanofludic systems is a topic of scientific interest both for the ability to create novel devices as well as for the practical understanding of how to replicate the function of membrane protein channels. Because nanopores have large surface to volume ratios, modification of the effective surface charge of a nanopore plays a large role in the nature of the ion transport through it. To this effect, we have prepared a novel ionic transistor from single conical nanopores in polymer films. Control of the ion current through these single conical nanopore transistors is achieved through the deposition of an electrically insulated gold thin film ''gate'' electrode on the side of the polymer film with the small nanopore opening. By changing the electric potential applied to the ''gate,'' the current through the device can be changed from the rectifying behavior of a typical conical nanopore, to the almost linear behavior seen in cylindrical nanopores. This ion current tuning can be achieved with gate voltages that are lower than 1 V. The mechanism for this change in transport behavior is thought to be the enhancement of concentration polarization due to the increase of the effective surface change that occurs with increasing ''gate'' bias. Application of this transistor system for directing and amplifying ionic and molecular fluxes in nanofluidic devices will be discussed.

3348-Pos Board B395

Sifting out Methylated DNA with Synthetic Nanopores

Winston Timp[1], Utkur Mirsaidov[2], Xueqing Zou[2], Klaus Schulten[2], Andrew P. Feinberg[1], Gregory Timp[2].
[1]Johns Hopkins University, Baltimore, MD, USA, [2]University of Illinois, Urbana, IL, USA.

Methylation of cytosine residues in DNA produces 5-methylcytosine, changing the protein binding affinity of the sequence, hence altering the organization and expression of the surrounding DNA. The pattern of methylation often silences genes, which physiologically orchestrates processes like differentiation, and pathologically leads to cancer. However, current methods for detecting methylation are either limited in resolution and sensitivity or are too expensive and time-consuming with current technology. Here, we report measurements of the permeation of methylated DNA through a synthetic nanopore, using an electric field to force single molecules to translocate one-at-a-time. For pores <3.0 nm in diameter_comparable to the DNA helix_we found an electric field threshold for permeation of methylated DNA that depends on the methylation pattern.